Acquisition Research Program:
Creating Synergy for Informed Change

Make or Buy: Cost Impacts of Additive Manufacturing, 3D Laser Scanning Technology, and Collaborative Product Lifecycle Management on Ship Maintenance and Modernization

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A DoD Technology Adoption Challenge

- Cost constrained DoD environment requires cost reduction
- Threats require US military to retain technological superiority
- Complex IT acquisition process
- **Improved ship maintenance and revitalization with advanced technology has potential for addressing these needs**
- DoD needs guidance on which technologies to adopt and how.

Potential Technology 1:
3D Terrestrial Laser Scanning

- Laser scans space from highly articulated mount, often combined with 360^{o} camera
- Software processes points into 3D image of the space. Processed into CADD format.
- Currently used in automotive, offshore construction and repair, civil and transportation, building construction, fossil fuel and nuclear power plants

Potential Technology 2:
Collaborative Product Lifecycle Management

- To “integrate people, processes, and information”
- Electronically integrates design documents, data bases, 3D LST, etc., for participant collaboration across physical distances & time.
- Common, shared sets of documents improves access, collaboration, coordination, communication
- Common platform for program change management
- Basis for asset management during operations

Potential Technology 3:
Additive Manufacturing
("3D Printing")

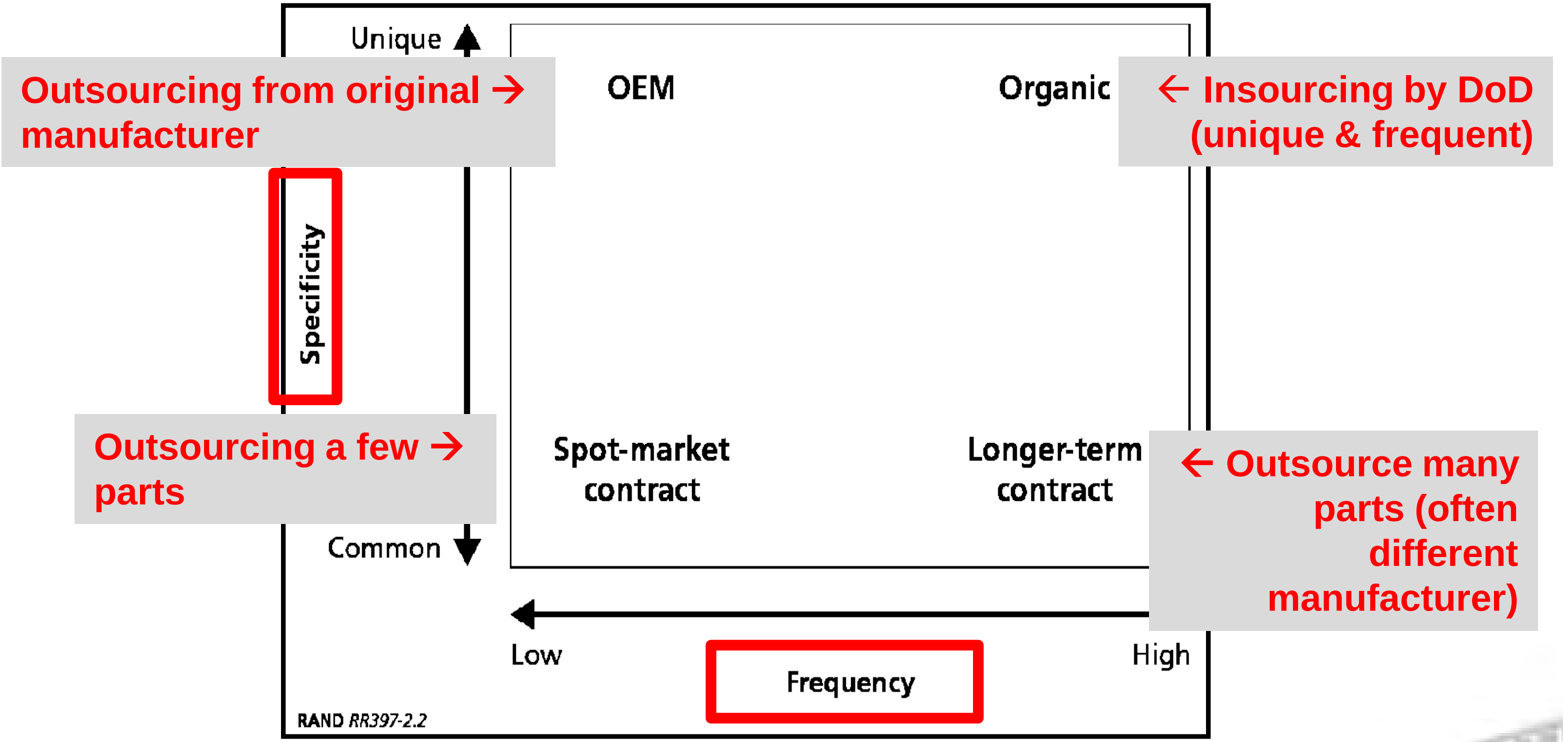
- 3D design/image (e.g. from 3D LS) of final part. Create net that describes surfaces.
- Geometric slicing of image into horizontal layers for manufacturing
- Incrementally add small amounts of material in very thin layers of material to build-up part
- Variety of possible materials (plastic, titanium) & methods (e.g. for material bonding)
- Very complex parts possible. Little waste.
- No dominant method, materials, suppliers

Problem Description

- **Outsourcing parts manufacturing for ship maintenance and revitalization is problematic:**
  - OEM often out of business
  - Costs can be very high for one/few parts (especially if unique or old)
  - Contracting is slow, degrading operational availability
- **In-sourcing has potential to reduce costs & improve performance, but has limited use.**

<u>Research Question</u>: How does 3D LST, CPLM, and Additive Manufacturing impact make/buy decision for Naval parts manufacturing?

A Model of DoD Make/Buy



A Conceptual Sourcing Framework (Drew, McGarvey, and Buryk, 2013)

- Unique parts provide most *benefit* to Navy (vs. to contractors)
- Frequently needed parts provide most *cost* savings (econ. of scale)

Hypothesis

- **Adopting advanced manufacturing technologies can reduce costs of insourcing some parts & increase attractiveness of insourcing.**
- **3DLST, CLPM, and Additive Manufacturing have the potential to generate large cost savings compared to traditional manufacturing by:**
  - Faster manufacturing reduces labor costs.
  - Reduced wasted material reduces labor and material costs
  - Eliminating need for traditional manufacturing equipment (e.g. large lathes and drill presses)
  - Making parts on demand reduces or eliminates parts inventories and infrastructures to maintain those inventories.
  - Reducing the space needed on ships to carry inventories and fabricating equipment.

Research Approach

Reverse-engineered investment analysis

1. **Describe the make-buy strategies**.
2. **Estimate revenues** that reflect benefits using a market-comparable approach based on field data.
3. **Estimate return on investment** (ROI) for each strategy using Knowledge Value Added models.
4. **Estimate costs** of each make-buy strategy.
5. **Estimate potential cost savings** by comparing costs of make-buy strategies.
6. **Value implementation strategies** using Integrated Risk Management.

Modeling Make/Buy Strategies

- Data collected from Fleet Readiness Center, San Diego

Part Complexity (% of total parts)		High (25%)		Medium (50%)		Low (25%)		Parts Produced by Industry	Parts Produced by Navy	Total Parts Produced
	Part Manufacturer	Industry	Navy	Industry	Navy	Industry	Navy			
% Made by Navy	0	6,750	0	13,500	0	6,750	0	27,000	0	27,000
	25	0	6,750	13,500	0	6,750	0	20,250	6,750	27,000
	50	0	6,750	6,750	6,750	6,750	0	13,500	13,500	27,000
	75	0	6,750	0	13,500	6,750	0	6,750	20,250	27,000
	100	0	6,750	0	13,500	0	6,750	0	27,000	27,000

Annual Production Rate Estimates
of Five Make-Buy Strategies

Modeling Benefits of Make/Buy Strategies

- SME: "{For complex parts} externally we see charges anywhere between $6,000 to $8,000 dollars and upwards of $15,000"

	Complexity (% of total	High (25%)		Medium (50%)		Low (25%)		Parts Value Produced by Industry ($1,000/yr)	Parts Value Produced by Navy ($1,000/yr)	Total Parts Value ($1,000/yr)
	Part Manufacturer	Industry	Navy	Industry	Navy	Industry	Navy			
	Avg. Part Value ($1,000/part)	6	6	3	3	1	1			
% Made by Navy	0	$40,500	$0	$40,500	$0	$6,750	$0	**$87,750**	**$0**	**$87,750**
	25	$0	$40,500	$40,500	$0	$6,750	$0	**$47,250**	**$40,500**	**$87,750**
	50	$0	$40,500	$20,250	$20,250	$6,750	$0	**$27,000**	**$60,750**	**$87,750**
	75	$0	$40,500	$0	$40,500	$6,750	$0	**$6,750**	**$81,000**	**$87,750**
	100	$0	$40,500	$0	$40,500	$0	$6,750	**$0**	**$87,750**	**$87,750**

Estimated Annual Benefits (*$1,000)
of Five Make/Buy Strategies

Modeling Return on Investment of Make/Buy Strategies

- Knowledge Value Added modeling method applied

Part Complexity (% of total parts)		High (25%)		Medium (50%)		Low (25%)	
Part Manufacturer		Industry	Navy	Industry	Navy	Industry	Navy
% Made by Navy	0	573%	NA	151%	NA	12%	NA
	25	NA	1120%	151%	NA	12%	NA
	50	NA	1120%	236%	510%	12%	NA
	75	NA	1120%	NA	358%	12%	NA
	100	NA	1120%	NA	358%	NA	103%

Estimated Returns on Investment (ROI)
of Five Make-Buy Strategies

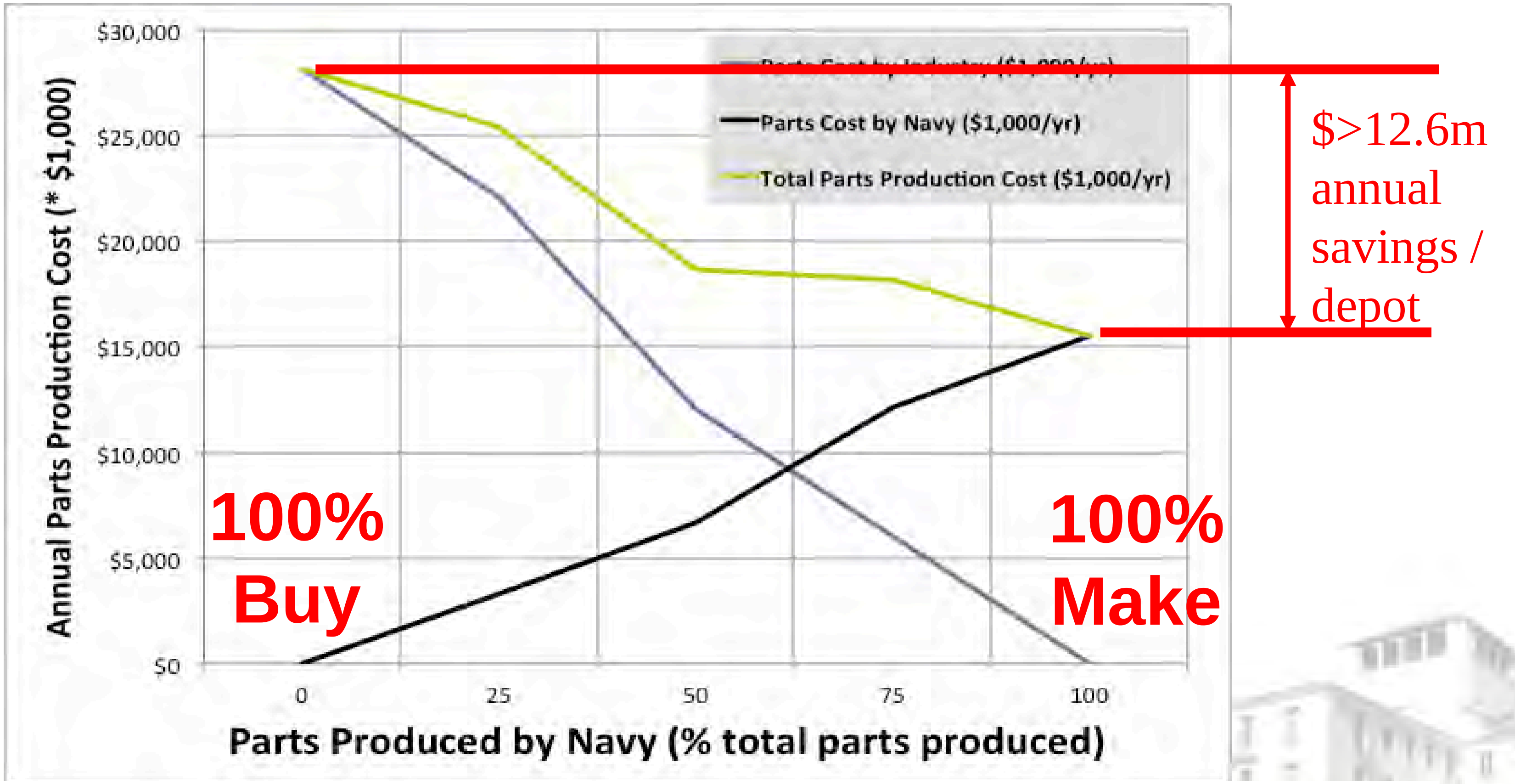
Estimated Costs and Savings

- ROI = (Benefits – Costs) / Costs

Part Complexity (% of total parts)		High (25%)		Medium (50%)		Low (25%)		Parts Cost by Industry ($1,000/yr)	Parts Cost by Navy ($1,000/yr)	Total Parts Production Cost ($1,000/yr)
	Part Manufacturer	Industry	Navy	Industry	Navy	Industry	Navy			
% Made by Navy	0	$6,022	$0	$16,109	$0	$6,022	$0	$28,152	$0	$28,152
	25	$0	$3,319	$16,109	$0	$6,022	$0	$22,130	$3,319	$25,449
	50	$0	$3,319	$6,022	$3,319	$6,022	$0	$12,043	$6,638	$18,681
	75	$0	$3,319	$0	$8,841	$6,022	$0	$6,022	$12,160	$18,181
	100	$0	$3,319	$0	$8,841	$0	$3,319	$0	$15,479	$15,479

Estimated Annual Costs (*$1,000)
of Five Make-Buy Strategies

Results: Estimated Costs of Make/Buy Strategies (one depot)



Estimated Annual Costs of Five Make/Buy Strategies

Threshold Savings for In-Sourcing

National Defense Authorization Act for FY2012:

“(e) ***…in determining whether a function should be converted*** [from outsourcing] ***to performance by Department of Defense*** civilian employees …the Secretary of Defense shall…ensure that the difference in the cost of performing the function by a contractor compared to the cost of performing the function by Department of Defense civilian employees would be equal to or exceed the lesser of…

(i) 10% of the personnel-related costs for performance of the function; or

(ii) $10,000,000

Modeling Implementation Strategies

- Modeled four strategies, each with exit option to (abandon)
- Monte Carlo simulation of scenarios reflect uncertainty of costs and success
- Production rates, costs, and savings from previous model used as input

Modeling Implementation Strategies

A: Base Case: Outsource (Buy) 75% of inventory. Opportunity losses occur due to missed financial savings and control over process.

B: Outsource (Buy) 100%. Leads to dependency on organizations outside control of the Navy.

C: Insource (Make) 100%: Invest in new technologies. ROI is high but cost & risks very high if it does not work.

D: Sequential adoption of technologies

- Phase I - Implement CPLM
- Phase II - Add 3D Laser Scanning Technology
- Phase III - Add Additive Manufacturing
- Phase IV - Full application to all components

Real Options Analysis Results

Strategy Path	Decision	Strategic Value	Notes
Strategy A	25% Navy As-I	62,300	AS-IS 25%
Strategy B	Buy 100%	59,597	Buy 100%
Strategy C	Make 100%	72,271	Make 100%
Strategy D	Phased	74,149	Stepwise

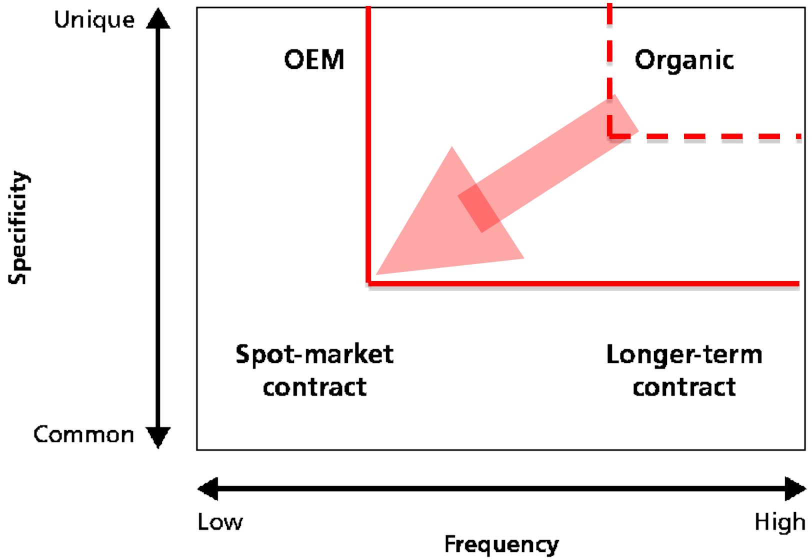
Phases	Cost	Timing
Phase 1 Cost	3,319	2 Years
Phase 2 Cost	3,319	4 Years
Phase 3 Cost	5,522	6 Years
Phase 4 Cost	3,319	8 Years
Total Costs	15,479	

The best strategy implements new technologies in phases, giving management the ability to exit at any stage of the project, while minimizing the risk of losses.

Conclusions

- Potential ***cost savings*** due to the adoption and use of the three technologies was estimated to be ***large and increase as more parts were manufactured by the US Navy*** (i.e. insourced).
- ***In-sourcing the manufacture of complex parts was found to generate the largest savings per part.*** Complex parts for which few copies are needed are the best candidates for initial insourcing using the technologies.
- ***Phased implementation provides the highest strategic value*** by giving management the ability to exit at any stage of the project.

Implications for Practice



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These technologies can move the make / buy boundary and increase the advantages of in-sourcing parts manufacturing

Recommendations:

- ***Adopt the three technologies*** investigated for parts manufacturing
- ***Test insourcing using these technologies.*** Start with low volume complex products.
- ***Plan to increase the scale of insourcing*** after developing processes and a track record to justify expansion.
- ***Work to change acquisition regulations and procedures*** that impede the use of insourcing for parts manufacturing.

Questions
Comments
Discussion

Issues for Future Research

- Xxxxxxxxxx

Knowledge Value Added